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PATENT APPLICATION TRANSMITTAL LETTER

ATTORNEY'S DOCKET NO.
KITCHLOO ET AT 339

TO THE COMMISSIONER OF PATENTS AND TRADEMARKS:

Transmitted herewith for filing is a patent application of - PARESH V. KITCHLOO and
ROBERT A. SALLAVANTI

FOR: INFUSION OF DYE USING A PLASTICIZER

ENCLOSED ARE:

- ☐ sheet(s) of formal drawing(s)
☐ an Assignment of the invention, with required cover sheet, to
☐ Priority is claimed under 35 USC 119 for the following application(s):

- ☐ a certified copy of the aforesaid application is enclosed.
☐ a certified copy of the aforesaid application will be submitted in due course.
☐ Associate Power of Attorney enclosed.

CLAIMS AS FILED

FOR	NUMBER FILED	NUMBER EXTRA	RATE	FEE
TOTAL CLAIMS	16	0	X \$18.00	\$ 0.00
INDEPENDENT CLAIMS	2	0	X \$78.00	\$ 0.00
BASIC FEE (\$690)				
REDUCED FEE (\$345) <input type="checkbox"/> Independent Inventor <input type="checkbox"/> Small Business Concern				\$690.00
TOTAL FILING FEE:				\$690.00

- ☐ Verified Statement of ☒ Independent Inventor ☐ Small Business Concern
☒ The Commissioner is hereby authorized to charge any additional fees which may be required at any time during the prosecution of this application without specific authorization, except for the Base Issue Fee, or credit any overpayment to Deposit Account No.19-1850. A duplicate copy of this sheet is enclosed.
☒ A Check in the amount of \$690.00 is enclosed. This check covers:
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☐ the filing fee and the Assignment recordal fee.
☐ Other _____

April 11, 2000

Date

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"EXPRESS MAIL" NO. EL 416 543 306Date of Deposit April 11, 2000

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04/11/00

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04/11/00

EXP. MAIL # EL 416 543 306

PTO

APPLICATION

OF

PARESH V. KITCHLOO

and

ROBERT A. SALLAVANTI

for

LETTERS PATENT

for

INFUSION OF DYE USING A PLASTICIZER

Title of the Invention

INFUSION OF DYE USING A PLASTICIZER

Field of the Invention

The invention relates to the infusion of dyes into the surface of an article formed of a plastic material using one or more substances each capable of plasticizing the material. More particularly, it relates to treating the surface of an article formed of a plastic material with a solution comprising one or more solvents each aggressive to said material, one or more dyes, and one or more substances capable of plasticizing the material.

Background of the Invention

Attempts have been made to introduce dyes into articles formed of a plastic material. For optical articles such as lenses, a thermoplastic frequently employed is polycarbonate, which is a condensation product resulting typically from the reaction of bisphenol A derivatives with phosgene. Many dyes degrade at the high molding temperature of polycarbonate. Accordingly it would be advantageous to treat the plastic article after it has been formed.

U.S. Patent 4,657,345 to Gordon utilizes aggressive solvents in combination with various heating steps. However, such surface defects as bubbling, hazing and crazing are caused by retained solvent. U.S. Patent 5,453,100 to Sieloff combines an aggressive solvent with a moderating solvent which acts to dilute and reduce the aggressiveness of the infusing solvent. This approach decreases the volatility of the solvent making it more difficult to drive off, resulting in increased bubble formation at or near the surface of the article. A variant of this approach is to utilize only non-aggressive solvents which reduces

solvent penetration and compromises dye density, for example, U.S. Patent 4,043,637 to Hovey, and U.S. Patent 4,323,597 to Olson.

Summary of the Invention

Our invention comprises treating the surface of a previously formed article of plastic material with one or more solvents aggressive to the plastic material having one or more dyes dissolved in the solvent and having further dissolved in the solvent one or more substances capable of plasticizing the material. It is preferable that the material have no plasticizer in it prior to formation of the article, since such would reduce the rigidity, strength and the mechanical properties of the formed article. The aggressive solvent enables penetration to depths in excess of 100 microns to achieve excellent dye density. The plasticizer is thought to provide sufficient polymer mobility to allow the solvent to almost completely escape during subsequent heating without causing bubbling, hazing or crazing. The extent of degradation of mechanical surface properties of the plastic article caused by retained plasticizer is negligible. It is the object of our invention to prevent bubbling and hazing of the surface of an article formed of a plastic material into the surface of which has been infused one or more dyes dissolved in one or more solvents each aggressive to the plastic by also dissolving in the solution one or more substances each capable of plasticizing the plastic material.

Description of the Preferred Embodiments

In the manufacture of optical devices, such as lenses, various dyes may be incorporated therein to affect the optical transmission characteristics. These dyes may include photochromic dyes, cosmetic tinting dyes, infrared absorbing dyes, laser radiation absorbing dyes and ultraviolet absorbing dyes. A combination of dyes may also be employed, for example, an ultraviolet absorbing dye to prevent

premature deterioration of a photochromic dye. Suitable photochromic dyes include palatinate purple, sea green, corn yellow and berry red which may be obtained from James Robinson, Ltd. of Huddersfield, United Kingdom.

A solvent aggressive to the plastic and also capable of dissolving the dye and a plasticizer is selected. An aggressive solvent is one which has a solubility parameter δ which, according to the theorem of Hildebrand, is within plus or minus 1 of the solubility parameter of the plastic when measured in $(\text{cal}/\text{cm}^3)^{0.5}$. Polycarbonate for example has a solubility parameter δ of $9.8 (\text{cal}/\text{cm}^3)^{0.5}$. Suitable aggressive solvents for polycarbonate are tetrahydrofuran ($\text{C}_4\text{H}_8\text{O}$, $\delta = 9.1$) and chlorinated hydrocarbons, for example, chloroform (CHCl_3 , $\delta = 9.3$), methylene chloride (CH_2Cl_2 , $\delta = 9.7$) and dichlorobenzene ($\text{C}_6\text{H}_4\text{Cl}_2$, $\delta = 10.0$). The aggressive nature of the solvent allows the dye to penetrate to a sufficient depth of 75 to 150 microns below the surface of the article, enabling good dye density. A combination of aggressive solvents may be used. The use of non-aggressive solvents is disadvantageous because they do not provide sufficient dye penetration and further may be difficult to drive off. Although acetone has a solubility parameter of 9.9, its use should be avoided, since it is too volatile and causes crystallization of polycarbonate. Further, dodecanol-1, having a solubility parameter of 9.8, is not recommended because even higher alcohols are somewhat hydrophilic and tend to absorb water vapor.

Plasticizers are sometimes used during manufacturing to give an otherwise rigid plastic flexibility; but as previously indicated we prefer that the plastic have no plasticizer prior to formation of the article. In the present application, the infused plasticizer provides local surface mobility to the plastic matrix, allowing the deeply penetrating solvent to almost completely evaporate during subsequent heating. Where the plastic is polycarbonate, the plasticizer may be selected from the following table which includes both acid and alcohol moieties.

Table 1 - Listing of Acceptable Plasticizers

Trade Name	Chemical Name	Chemical Formula
Benzoflex^(R) P-200	Polyethyleneglycol dibenzoate	$(C_2H_4O)_4C_{14}H_{10}O_3$
Benzoflex^(R) S-552	Pentaerythritol tetrabenzoate	$C_{33}H_{28}O_8$
DOP	Diethyl phthalate 98%	$C_6H_4-1,2-(CO_2CH_3)_2$
DPP	Dipropyl phthalate 99%	$C_6H_4-1,2-(CO_2CH_2CH_2CH_3)_2$
DMP	Dimethyl phthalate 99%	$C_6H_4-1,2-[CO_2CH_2CH(C_2H_5)(CH_2)CH_3]_2$
DOA	Diethyl Adipate 99%	$C_{22}H_{42}O_4$
DOS	Diethyl Sebacate 99%	$[-CH_2CH_2CO_2CH_2CH(C_2H_5)(CH_2)_3]_2$

One or more of these plasticizers may be used in combination. The plasticizers sold under the trademark BENZOFLEX^(R) may be obtained from Velsicol Chemical Corporation of Rosemont, Illinois.

The treating solution comprises the aggressive solvent or solvents, typically 1% to 4%, or more, by weight of plasticizer dissolved in the solvent and a conventional quantity of dye dissolved in the solvent. As a general rule, it is preferable to use the minimum concentration of plasticizer necessary to achieve the desired result. The polycarbonate article is contacted with the solution for at least ten seconds, but generally not more than one minute. In the case of a lens, one or both surfaces of the lens may be coated with the solution or the lens may be completely immersed in the solution. In the case of immersion, the article is removed from the solution at a uniform withdrawal rate. The solvent is then evaporated from the surface layer of the article by annealing. In practice, annealing consisted of heating the article from 85°F to 265°F in four hours and then cooling the article from 265°F to 85°F in one hour. It will be appreciated that the maximum temperature is appreciably less than the glass transition temperature of polycarbonate of 305°F. = 152°C.

The resulting dyed article is transparent, having a surface layer with a depth of the order of 75 to 150 microns, which contains the infused dye and

plasticizer and, likely, trace amounts of retained solvent, which in larger amounts would cause bubbling, hazing or crazing.

When polycarbonate lenses were contacted with chloroform containing no plasticizer, the lenses became hazy and developed bubbles after annealing.

A lens contacted with chloroform containing 1% of either of the BENZOFLEX^(R) plasticizers had some bubbling and hazing after annealing. Increasing the concentration of plasticizer to 4% provided undetectable bubbling and haze after annealing. The remaining plasticizers caused no haze at 1% concentrations and no bubbling at 4% concentrations. The results of tests appear in the following table. It will be understood that a 4% plasticizer concentration may be achieved by combining any four of the above plasticizers in 1% concentrations each.

Plasticizer Trade Name	Concentration	Bubbles after annealing	Haze
Control	No plasticizer	Yes	Yes
P-200	1%	Reduced in size	Reduced
	2%	Same	Same
	3%	Slightly less	Same
	4%	None	None
S-552 Solid	1%	Reduced	Greatly reduced
	2%	More reduced	Same
	3%	Same	Reduced
	4%	None	None
DOP 98%	1%	Reduced	None
	2%	More reduced	None
	3%	More reduced	None
	4%	None	None
DPP 99%	1%	Greatly reduced	None
	2%	Reduced	None
	3%	Reduced	None
	4%	None	None
DMP 99%	1%	Greatly reduced	None
	2%	Reduced	None
	3%	Same	None
	4%	None	None
DOA 99%	1%	Reduced	None
	5%	None	None
	8%	None	None
DOS 99%	1%	Reduced	None
	2%	None	None
	3%	None	None
	4%	None	None

Plastics other than polycarbonate would include polymethyl methacrylate (PMMA), $\delta = 9.09$, and polycarbonate-polyester copolymers (LEXAN), for which the foregoing solvents and plasticizers would be suitable, polystyrene (PS), $\delta = 8.56$, for which carbon tetrachloride, $\delta = 8.6$, methyl isopropyl ketone, $\delta = 8.5$, and propyl propionate, $\delta = 8.5$, would be suitable solvents and for which the foregoing phthalate plasticizers would be suitable, and polyethylene terephthalate (PET), $\delta = 9.5$, for which chlorobenzene, $\delta = 9.5$, and chlorostyrene, $\delta = 9.5$, would be suitable solvents and for which the foregoing phthalate plasticizers would be suitable. The glass transition temperature of polycarbonate is roughly $152^{\circ}\text{C}.$, while that of PMMA is $105^{\circ}\text{C}.$, that of PS is $100^{\circ}\text{C}.$, and that of PET is $80^{\circ}\text{C}.$ Of these thermoplastics, polycarbonate is the one for which our invention is especially useful, since for the other thermoplastics, there would be reduced dye degradation at the lower molding temperatures. It will further be understood that the maximum annealing temperature in each instance would be reduced to appreciably less than the glass transition temperature.

It will be seen that we have accomplished the object of our invention. We have prevented bubbling and hazing of the surface of an article formed of a plastic material into which has been infused a dye dissolved in a solvent aggressive to the plastic. This advantageous result is achieved by also dissolving in the solvent one or more substances each capable of plasticizing the material.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of our claims. It is further obvious that various changes may be made in details within the scope of our claims without departing from the spirit of our invention. It is, therefore, to be understood that our invention is not to be limited to the specific details shown and described.

Having thus described our invention, what we claim is:

The Claims

1. In a method of infusing a dye into the surface of an article formed of a plastic material, wherein the surface of the plastic article is contacted with a solution comprising one or more dyes dissolved in one or more solvents each aggressive to the plastic material and wherein the article is subsequently heated to evaporate the solvent or solvents, the step comprising dissolving in the solvent or solvents prior to contacting the surface of the article one or more substances each capable of plasticizing the plastic material.
2. The method of Claim 1, wherein each solvent has a solubility parameter measured in $(\text{cal}/\text{cm}^3)^{0.5}$ which is within plus or minus unity of that of the plastic material.
3. The method of Claim 1, wherein the solution is devoid of a solvent non-aggressive to the plastic material.
4. The method of Claim 1, wherein the solution contains at least 1% by weight of said substance or substances.
5. The method of Claim 1, wherein the dye is selected from the group consisting of photochromic dyes, cosmetic tinting dyes, infrared absorbing dyes, laser radiation absorbing dyes, ultraviolet absorbing dyes, and combinations thereof.
6. The method of Claim 1, wherein the article, prior to contact with the solution, contains no substance capable of plasticizing the material.

7. The method of Claim 1, wherein the article is immersed in the solution.
8. The method of Claim 1, wherein said surface is contacted for at least 10 seconds.
9. The method of Claim 1, wherein said surface is contacted for not more than one minute.
10. The method of Claim 1, wherein the article is heated during a first time interval from a first temperature to a second elevated temperature, less than the glass transition temperature of the plastic material, and then cooled during a second time interval shorter than said first time interval from the second elevated temperature to the first temperature.
11. A dyed article including in combination an article formed of a plastic material having a surface layer with a depth of the order of magnitude of 75 to 150 microns, said surface layer being infused with significant amounts of one or more dyes and one or more substances each capable of plasticizing the plastic material.
12. An article as in Claim 14 wherein the surface layer contains a trace amount of one or more solvents each aggressive to the plastic material.
13. The article of Claim 14, wherein the dye is selected from the group consisting of photochromic dyes, cosmetic tinting dyes, infrared absorbing dyes, laser radiation absorbing dyes, ultraviolet absorbing dyes, and combinations thereof.

14. An article, as in Claim 14 wherein the article contains no substance capable of plasticizing the material other than in said surface layer.
15. An article as in Claim 12 wherein each solvent has a solubility parameter measured in $(\text{cal}/\text{cm}^3)^{0.5}$ which is within plus or minus unity of that of the plastic material.
16. An article as in Claim 12 wherein the surface layer is devoid of a solvent non-aggressive to the plastic material.

Abstract

A method of infusing a dye into the surface of an article formed of a plastic material comprises contacting the surface with a solution including one or more solvents each aggressive to the plastic material, one or more dyes and one or more substances each capable of plasticizing the plastic material. If the plastic material is polycarbonate, then the aggressive solvent may be one or more chlorinated hydrocarbons. The dye may be a photochromic dye, a cosmetic tinting dye, dyes for absorbing infrared, laser and ultraviolet radiation, or combinations thereof. A wide range of plasticizers has been investigated. The article is contacted by the solution for ten seconds to one minute; and nearly all the infused solvent is then evaporated from the article by heating. The use of one or more plasticizers reduces or eliminates bubbling or hazing of the contacted surface during solvent evaporation. The dyed article comprises a surface layer having a depth of the order of magnitude of 100 microns containing one or more dyes, one or more plasticizers and, likely, a trace amount of the one or more aggressive solvents.

EXP. MAIL # EL 416 543 306

PVK

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

INFUSION OF DYE USING A PLASTICIZER

the specification of which (check only one item below):

☒ is attached hereto.

☐ was filed as United States application

Serial No. _____

on _____,

and was amended

on _____ (if applicable).

☐ was filed as PCT international application

Number _____

on _____,

and was amended under PCT Article 19

on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

COUNTRY (if PCT, indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY
(Includes Reference to PCT International Applications)

ATTORNEY'S DOCKET NUMBER
KITCHLOO ET AL - 339

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application Number)

(Filing Date)

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:

U.S. APPLICATIONS			STATUS (Check One)		
U.S. APPLICATION NUMBER	U.S. FILING DATE		PATENTED	PENDING	ABANDONED
PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (if any)			

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (List name and registration numbers):

RICHARD S. SHENIER, Registration No. 20,405;
SHENIER & O'CONNOR, Registration No. 19,298;
ALLISON C. COLLARD, Registration No. 22,532

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	RESIDENCE & CITIZENSHIP	CITY NORTH ATTLEBOROUGH	STATE OR FOREIGN COUNTRY MA	COUNTRY OF CITIZENSHIP INDIA
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	RESIDENCE & CITIZENSHIP	CITY DALTON	STATE OR FOREIGN COUNTRY PA	COUNTRY OF CITIZENSHIP USA
	POST OFFICE ADDRESS	POST OFFICE ADDRESS 104 MILES STREET	CITY DALTON	STATE & ZIP CODE/COUNTRY PA 18414 USA

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201 <i>Pareesh Kitchloo</i>	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
DATE <i>4th April 2000</i>	DATE	DATE

EXP. MAIL # EL 416 543 306

RAS

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

INFUSION OF DYE USING A PLASTICIZER

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on _____,

and was amended

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☐ was filed as PCT international application

Number _____

on _____,

and was amended under PCT Article 19

on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

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			<input type="checkbox"/> YES <input type="checkbox"/> NO
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U S. APPLICATIONS			STATUS (Check One)		
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ALLISON C. COLLARD, Registration No. 22,532

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2	FULL NAME OF INVENTOR	FAMILY NAME KITCHLOO	FIRST GIVEN NAME PARESH	SECOND GIVEN NAME V.
0	RESIDENCE & CITIZENSHIP	CITY NORTH ATTLEBOROUGH	STATE OR FOREIGN COUNTRY MA	COUNTRY OF CITIZENSHIP INDIA
1	POST OFFICE ADDRESS	POST OFFICE ADDRESS 12 ARROWHEAD CIRCLE	CITY NORTH ATTLEBOROUGH	STATE & ZIP CODE/COUNTRY MA. 02760 USA
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0	RESIDENCE & CITIZENSHIP	CITY DALTON	STATE OR FOREIGN COUNTRY PA	COUNTRY OF CITIZENSHIP USA
2	POST OFFICE ADDRESS	POST OFFICE ADDRESS 104 MILES STREET	CITY DALTON	STATE & ZIP CODE/COUNTRY PA 18414 USA

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